

LOW PRESSURE ATOMIZER FOR DIFFICULT TO DISPERSE SOLUTIONS

Field of the Invention

This invention relates to atomizing apparatus, in general, and more particularly to specific improvements in atomizing apparatus utilized for precisely controlled dispensation of finely dispersed and difficult to disperse solutions. One such application relates to deposition of paper coatings and sizing material onto moving webs of paper and paperboard. The atomizing apparatus can be also used in dispensing a mixture of highly reactive chemicals when high uniformity in the mixing process is desired.

Background of the Invention

The use of spraying technology for paper coating and sizing applications was tested in the early seventies. This was followed by efforts to apply this technology in a production environment, but the results were largely unsuccessful. The paper industry has been slow to embrace this process, citing potential efficiency impairments created by interruptions in continuous operations. Any such interruption is of great concern in this very capital-intensive industry where production plants must operate non-stop 24 hours a day, seven days a week to remain competitive.

Using spraying techniques to coat or size paper is, in principle, very simple, i.e., a set of nozzles in an applicator box to spray size or coating fluid. This process is shown in minute detail in U.S. patent 4,944,960 by Donnelly, Kangas and Sundholm, and further developed in their European patent EP 0682571. There have been further efforts to develop spray coating based on high pressure, small-opening nozzles operating at or above 100 bar pressure level, as shown by Koskinen et al. in US patent 6,060,449.

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While spraying with nozzles is certainly not a new process, creating a fine evenly distributed, controllable spray pattern was largely unachievable before the approach outlined by Winheim in U.S. patent 4,946,101. His patent outlines the historical development of spraying technology in detail, and also introduces the provision for adding a second gas stream via an outer nozzle. This implementation results in an enhanced dispersion capability, but lacked a thermal barrier and the ability to use lubricants and coolants.

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When air is used to spray highly viscous and fast-solidifying liquids containing a high concentration of organic and inorganic solids and chemicals, some of these sprayed liquids will crystallize or solidify rather quickly onto the nozzle outlet areas such as the nozzle tip or the outside area from where the dispersing air is released. After the deposit is formed, the spray pattern will be distorted and the process must be stopped to clean the nozzle. This is not acceptable for the paper industry, as mentioned earlier.

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Trouble-free spraying has been developed by this invention by preventing the viscous material from solidifying anywhere in the spray nozzle. This improvement to the current technology results from three factors:

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1. The nozzle and nozzle tip design as explained in this invention
2. Use of surfacing materials or nozzles made of heat barrier materials including various polymers.
3. Rendering the sticky material or liquid components harmless by preventing contact through lubrication or by dissolving the problematic liquid components (e.g., starch, clay, latexes etc.)

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OBJECTS OF THE INVENTION

An object of the invention is to provide a fully controllable spray apparatus for viscous and otherwise difficult to disperse liquids in such a way that the entire cross-section of the spray of atomized liquid contains minute droplets of liquid in uniform distribution.

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Another object of the invention is to provide an apparatus which can be used in coating and sizing stations for the paper and board industry to coat and size moving paper and board webs while achieving simultaneously full machine and cross-directional coating or sizing in liquid application control and moisture profiling.

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A further object of this invention is to provide an apparatus for low-pressure dispersion using pressurized gas in a nozzle that is especially designed to prevent the typical clogging problems associated with commonly used air-aided low pressure dispersion nozzles. This gas requires a minimum

specific moisture content depending on the material to be sprayed. The moisture can be provided by the dispersed lubricant, coolant or water, including steam.

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BRIEF SUMMARY OF THE INVENTION

According to this invention, an atomizer utilizes a swirling dispersing action that involves the seamless integration of two or three separate concentric nozzles. The solution to be dispersed is conveyed to the edge of the innermost nozzle where a swirling gas stream will break it into minute droplets in a uniform manner. The external surface of this innermost nozzle has a specific conical design and surface properties. The design objective is to minimize the surface available for solidifying droplets or other material to aid the swirling action and outward speed for the rapidly dispersing solution.

The middle nozzle forms a specially designed concentric pipe around the inner nozzle. Its external surface, together with that of the innermost nozzle, creates an aerodynamically designed entity to help enforce the swirling action and the outward speed by using the Coanda effect. The middle nozzle provides water, air or other chemicals as coolant to insulate the inner nozzle. This includes thermal barrier protection from excessive heat caused by steam and prevents any material from solidifying on the external surface of the inner nozzle.

The outermost nozzle provides the atomizing or dispersion force with pressurized agents such as air, gas, steam or a combination of these elements. The generated dispersion force has two components where the first, starting inside, creates the outward speed momentum and the second component causes the gas to rotate or swirl at high speed while moving towards the outermost edge of the nozzle.

The middle layer can be used for the outward speed momentum, especially when air or other gases are used as coolant.

The material used as well as the design of the inner nozzle is critical. The edge of the nozzle from which the solution exits must be sufficiently thin and sharp thereby minimizing the surface area available for crystallization or deposit accumulation. Wherever feasible, it is preferable to use nonstick coatings such as Teflon on surfaces exposed to the solution.

The apparatus provides for the possibility to implement quantity control of the elements flowing through the middle and inner nozzles, which in turn will open the opportunity to create a complete material and moisture profile control system through a single system. Such a device will be valuable in the manufacture of high quality paper and paperboard products. Sufficient gas pressure must be applied to get full dispersion of the intended liquids. A low pressure of 0.2 to 1.5 bar is sufficient for most coating and sizing liquids; however, the apparatus will withstand high pressure if needed in some other applications.

In an alternative arrangement, according to this invention, the middle nozzle and associated structure are eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of one embodiment of the atomizing apparatus;

FIG. 2 is a variation of the embodiment shown in FIG. 1 and illustrates an alternative implementation for the nozzle and delivery mechanism carrying gas, air or steam mixture;

FIG. 3 is a cross-sectional view to illustrate the entry nozzle and delivery mechanism for the gas, air or steam mixture in the two nozzle variation of the invention; and

FIG. 4 is a cross-sectional view of a further modification of the atomizer.

DETAILED DESCRIPTION OF THE INVENTION

The atomizing apparatus designated generally by the numeral 10, hereinafter referred to as the atomizer, shown in FIG. 1 comprises a substantially cylindrical housing or body 11, a first nozzle element 20 which receives air at relatively low pressure from an inlet into the housing 11, a second nozzle element 30 which receives a flow of water from a second inlet into the housing 11, and a third nozzle element 350 which receives a flow of liquid from a third inlet into the housing 11. The first nozzle element is integrated to an annular swirling or twisting member 40. The first inlet is defined by a first nipple 321 that extends substantially radial to the housing, the second inlet by a second nipple 322 that also extends

substantially radial to the housing and the third inlet by a third nipple **323** that extends axially from one end of the housing **11**.

The housing **11** is provided with a substantially axially extending channel **12** which communicates with the second nipple **322** and is defined in part by the slender elongated main section **31** of the nozzle **30**. The slightly conical front end portion of this section **31** extends beyond the nozzle element **20**, and the channel **35** has a water lubricant, coolant, air or gas discharging portion in the front end portion of the section **31**. The water-receiving portion of the channel **35** is provided in an extension **33** which forms part of the nozzle **30** and is received in the channel **12** of the housing **11** via nipple **322**. The outer diameter of the extension **33** matches or approximates the outer diameter of the channel **12**.

The first nozzle **20** defines, in part alone, in part with the second nozzle **30**, in part with the housing **11** and in part with the swirling member **40**, a composite channel **14** having a first portion which communicates with the first inlet nipple **321** of the housing **11** and an air discharging second portion **22** which is an angular orifice surrounding the section **31** of the nozzle **30**. The maximum diameter portion of the channel **14** communicates with the inlet which is defined by the nipple **321** by way of one or more passages which are provided in the housing **11** in front of and/or behind the plane of FIG1. The alternative embodiment for the location of nipple **321** is shown as nipple **321a** in FIG 2.

The housing **11** is provided with a substantially axially extending channel **324** which communicates with the third nipple **323** and is defined in part by the slender elongated main section **350** of the nozzle. The slightly conical front end portion of section **350** extends from the housing **11** of the atomizer **10** beyond the nozzle element **20** and the water discharging portion, channel **35**, in the front end portion of the section **31**.

In order to prevent the material flowing through channel **324** from solidifying, section **350** is made of plastic or other appropriate heat resistant material to form a thermal barrier. This is necessary because the material flowing from nipple **323** is cool whereas the steam or other substance flowing from nipple **322** is hot.

The housing **11** in FIG. 2 is further provided with at least one substantially radially extending taped bore **17** for reception of a portion of a threaded fastener (not shown) which secures the atomizer **10** to a support in a

machine for wetting webs of paper or other hygroscopic material. The wetting action can involve moving the housing 11 relative to the web and/or vice versa.

The front-end portion of the housing 11 (namely the end portion which is remote from the nipple 323) is provided with an internal thread 16 mating with an external thread 21 of the nozzle 20. The channel 14 includes an elongated portion 23 which is disposed between the nozzles 20, 30 and the cross-sectional area of which decreases in a direction towards the annular air-discharging portion or orifice 22. A larger-diameter section 24 of the nozzle 20 in the maximum-diameter portion of the channel 14 has a precision-finished cylindrical or conical internal surface 25 which closely surrounds and abuts a complementary cylindrical or conical external surface 34 on a section 32 of the nozzle 30. The outer diameter of the section 32 is larger than the outer diameter of the section 31 and/or extension 33, and the section 32 is a tight fit (such as a press fit or a sliding fit) in the section 24 of the nozzle 20. Thus, the internal surface 25 of the section 24 centers the nozzle 30 by way of the external surface 34 of the section 32.

When the improved atomizer 10 is in use, the nipple 322 is connected to a source of water, steam coolant, lubricant, air or gas by a hose or the like, not shown, so that the channel 35 of the nozzle 30 discharges a flow of water. The pressure of water issuing from the tapering end portion of the section 31 is relatively low, e.g., only slightly above atmospheric pressure but the atomizer will operate with efficiency at a pressure up to 100 bar.

The nipple 321 is connected to a source of pressurized air, e.g., to an air compressor, which admits air, gas or steam into the channel 14. The ports 26 convey the admitted gas from the maximum-diameter portion of the channel 14 into the portion 23 which surrounds the section 31 of the nozzle 30. A first part of the air stream which is admitted into the portion 23 is swirled by the member 40 to form a swirling stream having a ring-shaped cross-sectional outline and contacting the outermost layer of the flow of liquid issuing from the end portion of the section 31. The swirling stream of air circulates about the common axis of the nozzles 20, 30 and centering surfaces 25, 34. As the stream flows along and beyond the end portion of the section 31, it breaks up the adjacent layer of the liquid flow into minute droplets so that each layer is converted into a finely atomized flow of liquid particles. The pressure of atomized flow of liquid particles is fairly low which is highly desirable when

the flow is used to moisturize a moving web of paper, because the droplets of atomized liquid are readily accepted and retained by the web.

The nipple **323** is connected to a source of liquid, which is the surface treatment solution to be dispersed on to the paper web. The conical edge of the elongated portion **350** extends from the housing **11** of the atomizer **10** beyond the nozzle **20** and its edge is shaped to minimize surface area exposure. In addition, housing **11** is provided with seal rings **360**, **361** and **362**.

An alternative form of the invention is shown in FIG. 3 whereby air is admitted through nipple **321** and nozzle **20** as explained in connection with the version of the invention shown in FIGS. 1 and 2 and, as explained above, nipple **323** communicates with nozzle portion **350** in the dispersal of surface treatment solution. In order to isolate the surface treatment solution flowing through nozzle portion **350** from the air flowing from nipple **321**, thermal barrier **370** formed of heat resistant material such as suitable polymers is disposed between nozzle portion **350** and housing **11**.

Another modification of the invention is shown in FIG. 4 wherein greater flow capacity is achieved in channel **35** of the version shown in FIGS. 1 and 2. More specifically, the upper end of second nozzle element **30** terminated in an abutting relation with the lower edge of angular swirling member **40** such that the inner diameter of nozzle **30** is the same as the inner diameter of angular swirling member **40**. By this means and as shown in FIG. 4, the diameter of nozzle **30** is increased and results in a substantially increased flow of water through channel **35**.